THE OSCILLOGRAPHER

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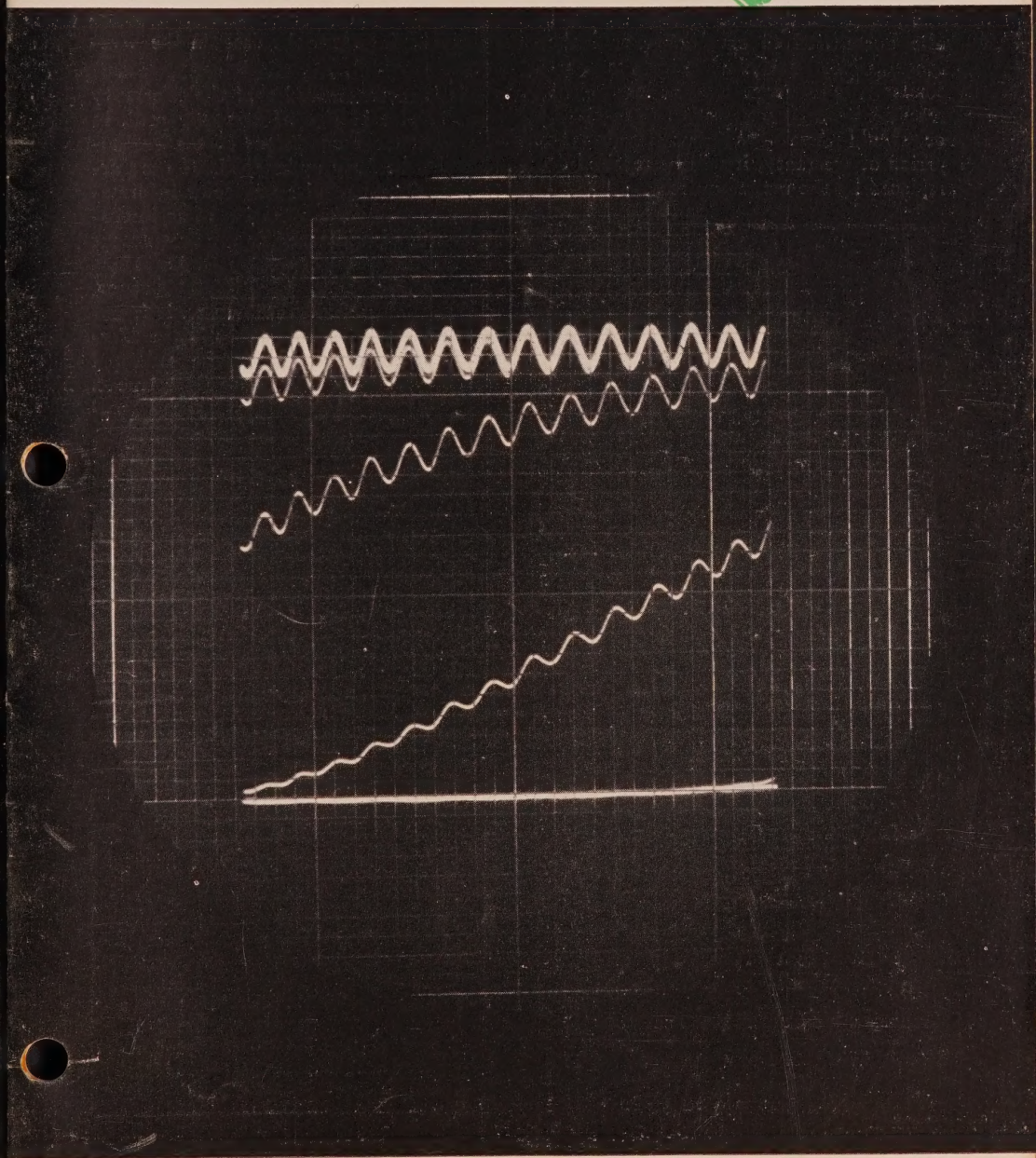

LIGHT OUTPUT OF AN INCANDESCENT LAMP

SEE PAGE 2

The Du Mont Guarantee

All instruments manufactured or sold by Allen B. Du Mont Laboratories, Inc., are guaranteed against defective materials, with the exception of the cathode-ray tube, and workmanship for a period of one year from the date of sale. They are also guaranteed to equal or exceed the specifications published for the particular type instrument. If an instrument should be found to be not as represented, or should develop a fault within the period of warranty, it will be repaired or replaced by the manufacturer.

A "Warranty Card" and a "Warranty and Service Notice"[1] are shipped with each instrument. The Warranty Card must be filled out by the purchaser and returned to the manufacturer before this guarantee can become effective. Warranty begins from the date on the Warranty Card.

It is recommended that the Warranty and Service Notice be carefully read, in order that the conditions of the guarantee may be fully understood. If the purchaser should require service or information regarding the operation of an instrument, he should write to the Instrument Service Department, Allen B. Du Mont Laboratories, Inc., 1000 Main Avenue, Clifton, New Jersey. However, it is important that the instructions in the Warranty and Service Notice be followed when writing to the Service Department. The type and serial numbers of the instrument in question should be given, along with a full description of the defect. Then, if the Service Department considers it necessary, authorization to return the instrument to the factory, and shipping instructions, will be forwarded.

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[1] With several instruments, the Warranty and Service Notice is printed at the end of the **Operation and Maintenance Manual.**

THE OSCILLOGRAPHER

A publication devoted exclusively to the cathode-ray oscillograph, providing the latest information on developments in equipment, applications, and techniques.

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ON THE COVER

Displayed on the cover of this issue is an oscillogram of the light-output characteristic of an incandescent projection lamp operating from an a-c source. This oscillogram was photographed from the screen of the Du Mont Type 250 Cathode-ray Oscillograph, operating on a low-frequency sweep, by the Du Mont Type 271-A Oscillograph-Record Camera. For additional details, see Page 7.

THE DU MONT TYPE 250 CATHODE-RAY OSCILLOGRAPH

A Discussion of This Versatile Laboratory Instrument, Its Design, and Capabilities

By

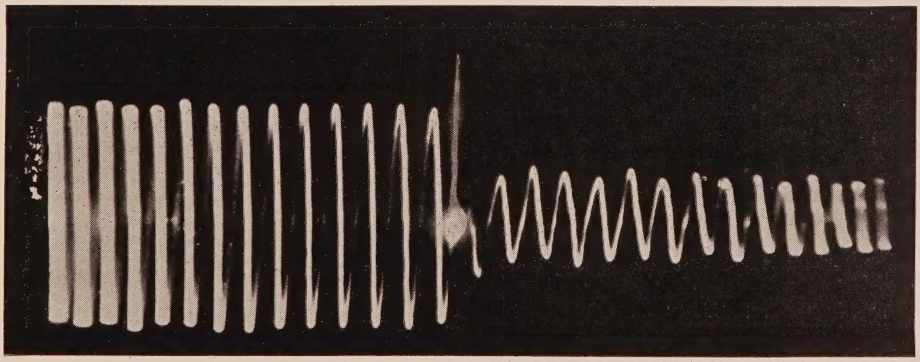
R. P. Abbenhouse[1]

THE cathode-ray oscillograph is recognized as one of the most useful tools for the observation of all manner of phenomena. With its chief requirement a transducer to transform the phenomenon under investigation into a variation of an electrical quantity, its field of application is virtually as broad as the field of technology itself.

Because of such a wide range of application, oscillographs of many different designs have appeared, each serving a particular function or group of functions depending on the original requirements giving rise to its design. On the other hand, designers of cathode-ray oscillographs have endeavored to create instruments that will perform adequately in as broad a field as possible.

The Du Mont Type 250 Cathode-ray Oscillograph is an example of such a general-purpose instrument. It was designed expressly as a versatile, laboratory oscillograph, and employs a Type 5CP-A Cathode-ray Tube operated at an accelerating potential of approximately 3000 volts; a-c and d-c amplifiers for both X- and Y-axis deflection; a sweep circuit providing both recurrent and driven sweeps; a voltage calibrator; and many other features making it useful for a great variety of applications. Signals may be applied directly to the deflection plates with positioning of the trace available at all times. Automatic beam control is provided so that on internal-sweep operation, the trace is visible only for the

Figure 1. *Starting characteristic of a synchronous motor as displayed on the Type* 250. *Pulse at center of pattern indicates action of centrifugal switch.*



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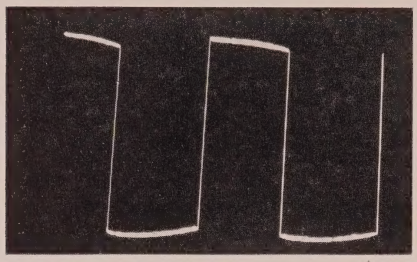

Figure 2. A four-cycle square wave as reproduced by the Du Mont Type 250 Cathode-Ray Oscillograph.

forward portion of the sweep, whether recurrent or driven. Also, the intensity of the cathode-ray beam may be modulated by an external source to permit time calibration of sweep velocity.

Deflection Amplifiers — Two channels of amplification are provided for X- and Y-axis deflection. In the Y-axis, a low-gain, stable d-c channel is available, through which a signal having both a-c and d-c voltage components may be applied to the cathode-ray tube. This amplifier consists of an input cathode follower direct-coupled through a d-c balanced gain control to the cathode-coupled, push-pull output amplifier, which is in turn direct-coupled to the deflection plates of the cathode-ray tube. A high gain, a-c channel is brought into service by turning the Y-Selector Switch, which inserts a two-stage capacitive-coupled amplifier between the input cathode follower and outut amplifier, and which adds suitable capacitive couplings elsewhere in the circuit for proper performance.

In the X-axis, a direct-coupled amplifier, identical to the low-gain d-c channel of the Y-axis, provides a d-c-amplifier channel. Amplification of a-c is accomplished by changing the setting of the X-Selector Switch, which inserts a coupling capacitor between the X-input terminals and the input tube.

The time constant of the a-c amplifier circuits was selected to assure good response at low frequencies, while it renders negligible the undesirable effects resulting from overloading the amplifiers.

By maintaining the deflection plates of the cathode-ray tube at approximately +200 volts with respect to ground, the stray capacitance introduced by the d-c coupling network that would otherwise be required, is eliminated. This enhances the high-frequency response of the instrument. The high-frequency response of all amplifier channels is essentially the same, differing only by an amount comparable to the normal errors of steady-state frequency-response measurements. Thus the frequency range of the Type 250 extends from zero frequency to 500 kc, where amplification falls to 70 per cent of normal response.

Signals of frequencies above the response region of the amplifiers, or having sufficient amplitude that amplification is unnecessary, may be applied directly to the deflection plates through terminals on the front panel. These terminals are coupled capacitively to the cathode-ray tube. Channel selector switches for both X- and Y-axis disable the amplifier channels for this purpose.

Z-axis-input terminals permit connection of signals for intensity modulation of the cathode-ray beam for time

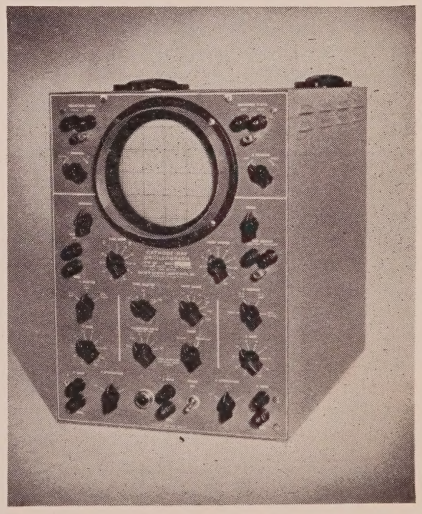

Figure 3. The Du Mont Type 250 Cathode-ray Oscillograph.

calibration. No amplifier is provided, but as little as 2.5 volts peak amplitude is sufficient to produce visible modulation of beam intensity.

Identical RC-compensated high-impedance attenuators are provided at the X- and Y-input terminals, enabling attenuation ratios of 1:1, 10:1, and 100:1 to be applied to the input signals. In addition, the instrument is supplied with a shielded probe for high-impedance applications. X- and Y-gain controls are arranged so that at the minimum gain setting, amplifier gain is 10 per cent of maximum gain. This correlation of operation of attenuators and input-gain controls will facilitate amplitude calibration of input signals having widely varying amplitudes.

The voltage calibrator, available for use with the Y-axis amplifiers, applies a square wave of 0.01, 0.1, 1, 10, or 100 volts peak-to-peak amplitude, depending on the setting of the Range Selector Switch. This signal is connected to the input of the amplifier, ahead of the attenuator, to afford direct calibration of the amplitude of an input signal.

This square wave calibrating signal is obtained by taking an a-c voltage from the secondary winding of the power transformer and feeding it to a dual-diode clipper, which is biased by a well regulated d-c voltage. One portion of the dual-diode clips the positive half-cycle of the a-c voltage, while the other clips the negative half-cycle. Together they create a square wave of 60 cps, whose amplitude is accurate to better than 5 per cent. The accuracy of the calibrator is limited only by the bleeder resistor, which is accurate to 2 per cent, and by the inherent instability of the dual-diode and voltage regulator circuit, which is 2 per cent.

Time Base — The time base provided in the Type 250 is a linear sawtooth voltage generated by a high-vacuum-tube circuit. It is capable of providing recurrent sweeps from 1 cps to 150 kc, or driven sweeps of 1 second to 20 microseconds duration. The sweep may be synchronized or driven internally from the Y-axis signal, externally by a signal

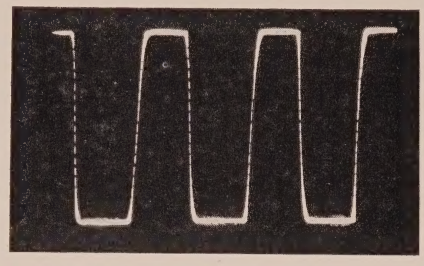

Figure 4. A 100-kc square wave as photographed from the screen of the Type 250.

applied to an External-Sync input terminal, or by an internal sinewave of power-line frequency. Synchronizing sensitivity of the recurrent sweep on Internal Sync is such that a Y-axis deflection of 0.1 inch or more is sufficient to obtain a stable, synchronized pattern. Snychronizing sensitivity on External Sync is such that approximately 0.05 volt peak is sufficient for a stable synchronized pattern. The driven sweep may be initiated when the Y-axis deflection is 0.5 inch or more on Internal Sync and from a signal of no less than 0.5 volts peak, applied to the External Sync terminal. Although the driven sweep may be initiated by a recurrent sinusoid of as low a frequency as 30 cps, a pulse or transient wave form is displayed to the best advantage on this type of sweep.

To assure optimum sweep linearity over the entire range of sweep operation, a portion of the sweep voltage is fed back into the sweep generator in the same phase. Thus a correction of linearity is effected. The sweep voltage is applied to the horizontal plates of the cathode-ray tube through the X-axis d-c amplifier. Sweep amplitude is variable from approximately one inch to twice full scale over most of its frequency range.

Provisions are made in the Type 250 to blank the electron beam of the cathode-ray tube during the return trace on recurrent sweep operation, and to unblank the beam during the forward portion of the driven sweep. Thus, in either type of operation, the trace is visible only during the useful portion of the sweep. For beam blanking during recurrent-sweep operation, a narrow pulse,

corresponding to the retrace interval, is taken from the common cathode of the sweep-generator tube. This pulse is amplified and then applied with negative polarity to the grid of the cathode-ray tube. Beam control for the driven sweep is accomplished by employing a signal corresponding to approximately the leading 75 per cent of the sawtooth wave generated by the sweep circuit. This signal is fed to a saturated amplifier circuit where a gate-type wave form is generated. This gate operates a flip-flop circuit, the output of which is applied to the grid of the cathode-ray tube, brightening the trace during the forward sweep.

The beam-gate circuit is in series with the negative high-voltage bleeder. Thus the need for an independent high-voltage supply for beam blanking is eliminated.

This beam-control feature is particularly valuable in making photographic recordings from the oscillograph. In recording transients, for example, with the oscillograph operating on driven sweep, the shutter of the camera may be left open until after the trace has appeared on the screen with no danger of fogging the film by a luminescent spot or line that appears either before or after the transient.

Two test signals are available at the front panel of the Type 250: a sawtooth signal having an amplitude of approximately 10 volts peak, taken from the sweep circuit, and a sinewave of power-line frequency with an amplitude of approximately 3 volts, rms. The sawtooth signal is valuable for such uses as a time base for another oscillograph or as a modulating or timing signal for other apparatus.

The Du Mont Type 250-H — Another version of this instrument, the Du Mont Type 250-H, is also available. The Type 250-H has all the features of the Type 250, but is equipped with a Type 5RP-A Cathode-ray Tube rather than a Type 5CP-A. The accelerator anode potential in the Type 250-H may be either the internal positive high-voltage supply of 3000 volts with respect to ground, or an external positive high-voltage supply of up to 15,000 volts with respect to ground. A simple plug-and-jack arrangement inside the instrument allows the operator to select either the internal supply or an external supply. The Type 250-H is designed to operate with the Du Mont Type 263-B High-Voltage Power Supply, which connects to a receptacle at the rear of the instrument, and furnishes up to 12,000 volts for such purposes. By applying the higher accelerating potentials, the light output of the cathode-ray tube may be increased up to 16 times that for the lower accelerating potential, while deflection sensitivity is reduced by no more than 50 per cent at maximum accelerating potential.

The Type 5RP-A Cathode-ray Tubes are supplied with the two common screen materials, the Types P2 and P11, although other materials are available on special order. The choice of screen material depends largely on the application for which the instrument is intended.[2]

Photographic recording of phenomena displayed on either the Type 250 or Type 250-H is a simple matter when either the Type 271-A or Type 314 Oscillograph-record Camera is used. These may be easily attached to the oscillograph, and they are extremely simple to operate.[3] With the Type 250-H operated at high accelerating potential, a photographic recording of a high-speed transient, which would be hardly visible at lower accelerating potentials, is of normal contrast.

Applications — The Type 250 has proved itself in all the well established applications of cathode-ray oscillography to amplifier design, receiver alignment problems, trouble shooting in electronic circuits, and the like.

An interesting specific application is found in the design of power supplies where the d-c amplifiers in the Type 250 provide a means for observing the voltage and current conditions. Both a-c and

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2. See "An All Purpose Screen for High-Voltage Cathode-ray Tubes" by R. Feldt, **The Oscillographer**, Vol. 9, No. 4, July-August, 1947.

3. See "The Type 271-A Oscillographer-Record Camera" by Carl Berkley in **The Oscillographer**, Vol. 10, No. 1, January-March, 1948; and "A New, Versatile Camera for the Cathode-ray Oscillograph," by H. P. Mansberg in **The Oscillographer**, Vol. 9, No. 4, Oct.-Dec., 1948.

d-c components can be seen simultaneously, and their relative magnitudes may be measured accurately with the aid of the built-in voltage calibrator. Surge voltages on filter capacitors during initial starting can be observed and measured through the d-c amplifier, whereas meter-type instruments, having mechanical inertia, cannot always follow such changes.

Another application in which the Type 250 has proved particularly valuable is the measurement and analysis of the light output of incandescent lamps. The light is picked up by a photocell and measured through the d-c amplifier, with the oscillograph operating on a low-frequency sweep. The photocell, acting as a transducer, provides a d-c voltage whose magnitude depends on the light intensity, and which magnitude can be readily measured by the built-in voltage calibrator.

On the cover is shown an oscillogram of the characteristics resulting from the operation of a projection lamp from an alternating-current source. The lower trace is a reference base line representing zero light output, while the pattern near the top represents the light output level consisting of a steady value plus a ripple component due to the alternating current passing through the filament. In this oscillogram the rise from zero to maximum light output is indicated by the three traces between the base line and the maximum level. Both time and amplitude calibration are possible with the aid of the ripple (source) frequency and the built-in voltage calibrator. More detailed examination of the ripple component can be made by merely switching over to the a-c amplifier channel and increasing the gain. A similar procedure is applicable to the study of fluorescent light sources.

The Type 250 is also used widely to investigate the starting characteristics of electric motors. For this application a slow-speed driven sweep of, say, one-half second duration is used. The sweep is initiated by switching on the motor. The motor current is observed through a small resistor in series with the supply current. For d-c motors, the 60 cycle test signal in the instrument provides a sweep calibrating signal so that the time required to attain full speed may be determined. The d-c amplifier is used so that the time between starting, where current is high, and full speed, where current is low, may be readily measured. For a-c motors, the time from starting to full speed is determined by counting the number of cycles to the point where the amplitude of the current reaches a steady value. The action of any associated regulator switches can also be readily seen.

The operation of the electronic-counter circuits depend upon sharp transitions from one d-c voltage level to another in the flip-flop elements of the counter. Accurate determination of these levels is possible with the aid of the voltage calibrator, the d-c amplifier, and either a driven or recurrent sweep, depending on convenience. The rate of change from one level to the other may also be measured with the Z-axis input serving as a convenient means for injecting a sweep-speed calibrating signal.

At this point it might be well to note that the driven sweep can be utilized to its fullest advantage only when its operation is thoroughly understood. The driven sweep is generated in such a way that the normal rest position of the undeflected beam is at the right edge of the cathode-ray tube. Upon application of an initiating pulse the beam moves quickly to the left and then it proceeds to the right for the forward and visible por-

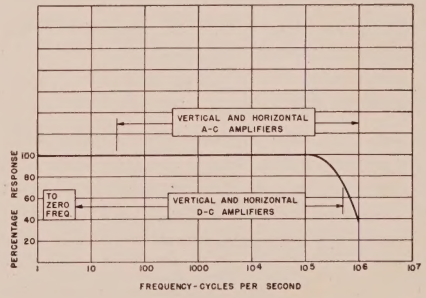


Figure 5. Curve showing the frequency response of the deflection amplifiers of the Type 250.

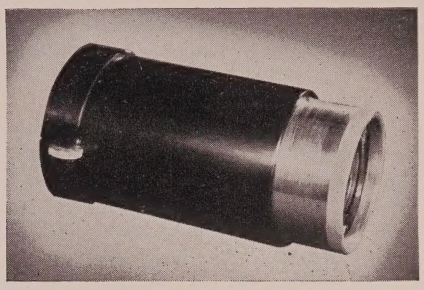


Figure 6. The Du Mont Type 2542 Projection Lens for projection oscillography with such instruments as the Type 250-H.

tion of the sweep cycle. The right to left traverse represents an increment of time which may be called sweep starting time and amounts to approximately 10 per cent of the time consumed for the forward or left-to-right traverse of the beam. This time must be taken into account in interpreting the display on the face of the cathode-ray tube.

Since d-c amplifiers are available for both X- and Y-axis deflection, both the static and dynamic characteristics of electronic circuit elements may be visually plotted on the cathode-ray tube. In this category of applications are found the vacuum tube, the transistor, non-linear resistors such as thyrite, and crystal rectifiers. In this case a zero-reference point is established by suitable positioning of the beam, and the independent variable such as, for example, input voltage provides the abscissa, while output current (measured as voltage across a resistor perhaps) provides the ordinate of the plot of static or dynamic characteristics, depending on the source of input voltage and output metering circuit.

Applications of the Type 250-H — The high-voltage version of this instrument, the Type 250-H, extends the field of application to transient phenomena of high speeds. In the field of ballistics, for example, the Type 250-H is particularly useful to display the variation of pressure with the time of flight of a projectile. The passage of a projectile through a barrel is of the nature of a single transient. A pressure-type pick-up is used as a transducer. Thus, by using a driven sweep of the proper speed, triggered by the firing of the gun, and applying a high accelerating potential to the cathode-ray tube, a brilliant trace of the phenomenon is obtained.

The Du Mont Type 2542 Projection Lens can be easily attached to the Type

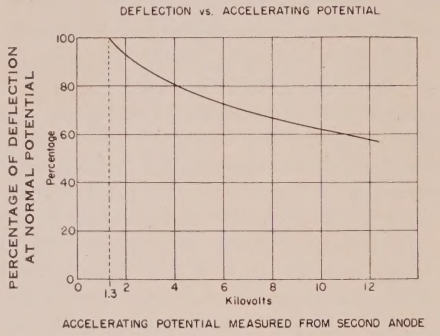


Figure 7. Deflection sensitivity vs. accelerating potential of the Type 250-H.

250-H. Thus equipped, the Type 250-H throws a large (up to 12 feet by 12 feet) clear image of the cathode-ray pattern upon a conventional projection screen, making the instrument extremely useful for lectures and demonstrations.

Catalog No.	Type No.	Description	Code Word
1303-E	250	Cathode-ray Oscillograph, for 115 volts, 50-60 cycles; with 5CP1-A Cathode-ray Tube	YALED
1304-E	250	Same as above; with 5CP2-A Cathode-ray Tube	YALEE
1307-E	250	Same as above; with 5CP11-A Cathode-ray Tube	YALEH
1308-E	250	Cathode-ray Oscillograph, for 230 volts, 50-60 cycles; with 5CP1-A Cathode-ray Tube	YALEJ
1309-E	250	Same as above; with 5CP2-A Cathode-ray Tube	YALEK
1312-E	250	Same as above; with 5CP11-A Cathode-ray Tube	YALEN
1314-E	250-H	Cathode-ray Oscillograph, with Type 5RP2-A Cathode-ray Tube; for operation from 115 volts, 50-60 cycles	YALEP
1317-E	250-H	Same as above, with Type 5RP11-A Cathode-ray Tube	YALES
1319-E	250-H	Cathode-ray Oscillograph, with Type 5RP2-A Cathode-ray Tube; for operation from 230 volts, 50-60 cycles	YALEU
1322-E	250-H	Same as above, with Type 5RP11-A Cathode-ray Tube	YALEX

ON IMPROVING THE PERFORMANCE OF THE TYPES 248 AND 248-A CATHODE-RAY OSCILLOGRAPHS

As with other products of industry, modifications of electronic equipment are made occasionally to improve performance and quality. Statistical information on a reasonable number of instruments enables the determination of design discrepancies so that corrections and improvements can be made.

The purpose of this article is to acquaint the reader with such improvements made in the Du Mont Types 248 and 248-A Cathode-ray Oscillographs and to indicate how these may be incorporated into older instruments of this type.

Since the modifications outlined below have been made as routine in the course of manufacturing the Types 248 and 248-A Oscillographs, the most recently manufactured instruments will have all of the changes already incorporated.

The circuits of the Types 248 and 248-A Oscillographs in which modifications were made are:

1. Beam brightening circuit (V107A and V109)
2. Sweep circuit
   (a) Sweep multivibrator (V115B and V117)
   (b) Sweep charging tube (V115B)
   (c) Constant-current discharging circuit (V116)
   (d) Input circuit of cathode follower (V118)
3. Marker generator
4. Sync amplifier
5. Regulated power supply
6. Cathode-ray tube, second anode.

Operation of the sweep, unblanking, and synchronizing circuits — Tubes V115B and V117 constitute a relaxation oscillator of the multivibrator type. Coupling between the suppressor of V117, which acts as a control grid, and

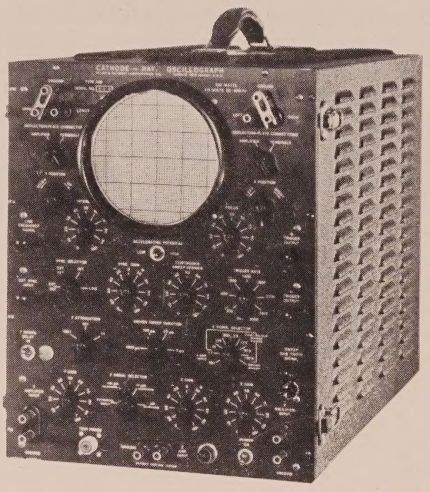


Figure 1. The Du Mont Type 248 Cathode-ray Oscillograph.

the plate of V115B is through capacitor C149. Between the grid of V115B and the plate of V117, coupling is achieved through the cathode-loaded impedance transformer V115A. This free-running multivibrator can be synchronized by applying a signal on the control grid of V117. The relaxation oscillator has a non-uniform square-wave output signal. However, because of the different time constants used, the waveform at the grid of V115B more nearly resembles a positive pulse. The duration of this pulse is of the order of one tenth of the repetition rate.

Subject to the sweep range in use, one of the sweep capacitors (C151 to C157) charges to approximately 100 volts through V115B. At this voltage V115B is driven to cut-off by the multivibrator action of V115B and V117. With V115B cut off, the sweep capacitor discharges linearly through the constant-current tube V116. The electrode voltages for

this pentode are chosen so that the plate-current drain remains constant for large changes in plate voltage. Variation of the value of the plate current as controlled by the grid bias suggests a convenient means for vernier control.

The resulting sawtooth-voltage output, taken from the plate of V116, is directly coupled to the cathode follower V118 and through the "H"-gain control to the horizontal-deflection amplifier.

The wide positive pulse at the suppressor of V117 is fed into the phase-inverter stage V107-A of the Z-axis amplifier circuit. Here this pulse is amplified, inverted, and passed on to the amplifier V109 as a blanking pulse. Since the output circuit of V109 is in parallel with the output of V108, the blanking pulse is mixed with the Z-axis signal, and it is applied through the 0.1μf, 3000-volt coupling capacitor to the grid of the cathode-ray tube.

The synchronizing signal is fed into the phase-selector tube V106B, where either a positive- or negative-output signal can be taken off the sync-gain control. The signal is directly coupled to and amplified by V121 and it is applied to the grid of the control tube V117 through the coupling capacitor C158.

For driven sweep operation, the control tube V117 is replaced by the cathode-coupled multivibrator circuit employing V122 and V123. This circuit is normally triggered into one cycle of operation by each positive, output signal from the sync amplifier V121. The signal at the plate of V122 is a negative, square pulse of duration that is determined by the time constant which is selected by switch S108 for the grid circuit of V123. This negative square pulse is coupled to the cathode follower V115A, thereby cutting off its plate current and in turn cutting off plate current in the sweep charging tube V115B. The sweep capacitors C178 to C181, inclusive, are discharged linearly, as before, by V116. The positive pulse at the plate of V115B is then amplified by V107A and V109 to form a brightening pulse for the grid of the cathode-ray tube for the duration of the driven sweep. The negative pulse appearing at the grid of V115B is also applied to the marker circuit, V110—V114, so that time-calibrating markers are available for calibrating the driven sweeps.

Description of Modifications — The modifications that have been made in the Types 248 and 248-A Cathode-ray Oscilographs have resulted in much more reliable performance of the above-mentioned circuits. The following paragraphs describe these modifications:

1. Beam brightening circuit (V107A and V109) — In the course of manufacturing these instruments, it was found that the beam-brightening signal, devveloped during driven-sweep operation, was often of insufficient amplitude to drive the grid of the cathode-ray tube from cut-off bias to full intensity. This was corrected by changing the components in the cathode circuit of V109A and V109B so as to increase the over-all gain of this amplifier circuit. A by-pass capacitator C205, 25 μf 50 v, was added across R145, and the resistance of R150 was reduced from 150 ohms to 68 ohms so that the voltage amplitude at the plate of V109 is sufficient for beam brightening.

However, as a result of this change a dark spot appeared at the beginning of the trace on high-frequency recurrent sweeps, thereby indicating Z-axis modulation. This modulation is caused by improper damping of L111 in the plate circuit of V115B so that on the trailing edge of the return-trace blanking pulse, corresponding to the left end of the sweep trace, the first cycle of a damped orcillation that is set up in this coil results in blanking of the trace. By reducing the resistance of the damping resistor R194 from 1500 ohms to 180 ohms this oscillation was suppressed.

The power rating of R147 has also been changed from one watt to two watts to prevent damage to this resistor.

2. Sweep circuit (V115, V116, and V117 — An improvement in the linearity of the sawtooth-sweep signal generated in this circuit has been accomplished

by a somewhat radical change. Inasmuch as a constant-current pentode is used to discharge a capacitor to generate the sawtooth-sweep signal, the rate of discharge is linear only to a certain point on the tube-characteristic curve. An adjustable linearity control was added as a load resistor in the plate circuit of V118 to permit factory adjustment to compensate for this limitation. By this means a sawtooth voltage 180 degrees out of phase with the generated sawtooth voltage on the plate of the cathode follower V118 is applied to the screen of the constant-current tube V116 through the added coupling capacitor. This operation necessitates the addition of two components, a potentiometer, R281, 2000 ohms 2 watts, and an electrolytic capacitor, C204, 8μf 450 v. This change makes almost perfect compensation for non-linearity of sweep.

Because a positive sawtooth voltage is applied to the screen of V116, the discharge current was increased somewhat, thereby changing the calibration of the sweep ranges. To correct this condition, it was necessary to increase the capacitance of the sweep capacitors C153 to and including C157 to 390μf, 2200μf, 0.01μf, 0.04μf and 0.2μf respectively. This was also applicable to the driven-sweep capacitors C178 to and including C181. However, instead of changing the capacitances of the capacitors in the latter group, a resistor R283 having a value of 330 ohms was connected between the most clockwise contact on the second section, rear, of the X-signal selector switch and ground to adjust the bias on the grid of V116 to the proper value. This modification compensates for the change in plate current that is caused by the linearity-correcting voltage applied to the screen of V116 on driven-sweep operation.

Other changes were made in the sweep circuit to increase overlap of the various ranges of the recurrent-sweep selector, to reduce sawtooth distortion on the low-frequency sweep ranges, and to change the d-c levels in the circuit to prevent overloading of the cathode follower V118. Overloading of V118 results in non-linearity or "packing" at the beginning and end of the sweep trace. These modifications consist of changing R199 in the plate circuit of V117 from 100K to 68K and the addition of R285, 2.75K-½W, between the cathode terminal of V115A, pin 3, and the junction of R195 and the grid terminal of V115B, pin 4. C148 and R196 remain connected to pin 3 o of V115A, however. This can be very simply accomplished by removing the jumper between pins 3 and 4 and replacing it with the resistor. This operation results in the proper connection of the other components mentioned. These changes achieve in a reduction of sawtooth amplitude applied to V118 as well as an adjustment of d-c voltages to the proper levels.

A tendency for grid current to flow in the X-axis amplifier tube V119, when the driven-sweep sawtooth signal was applied, was corrected by reducing its operating bias. This was accomplished by lowering the resistance of R210 from 15,000 ohms to 8,200 ohms.

3. Marker generator circuit — A number of changes were made in the time-calibrating marker circuit to improve stability and to provide sharper marker pulses. These changes are mostly mechanical; and they involve the placing of certain critical components, such as coupling components, in more suitable positions to shorten lead lengths within the circuit. Stray capacitance in the circuit is thereby reduced so that the frequency response of the amplifiers V112 and V113 is substantially increased. This improves the shape of the timing marks available from the one-microsecond range of the marker-selector switch. Incidental to this change is the elimination of multiple, one-microsecond marks appearing on the five-microsecond driven sweep. This condition formerly appeared as multiple blanking of the trace at each one-microsecond mark. Correction is accomplished by connecting a damping resistor, R284, of 2200 ohms, across the series-peaking coil L105 in the common plate circuit of V108 and V109. This resistor prevents a damped oscillation in the coil similar to the oscillation in the plate circuit of V115B, as previously described.

4. Sync Amplifier — To improve synchronizing ability at low signal-to-sweep-

frequency ratios, the sync phase selector V106B may be isolated from the regulated voltage supply with a decoupling circuit. The addition of R282 and C206, 4700 ahms and 8μf respectively, to the plate circuit of V106B isolates this circuit from the sharp surges that occur in the regulated supply coincident with the return-trace blanking pulse.

5. Regulated power supply — From time-to-time it has been reported that an unusual amount of ripple was observed in the regulated power supply. This was found to be due to several factors, including insufficient current flow in the glow-discharge tube VR105 (V132), long leads in the regulator amplifier, and considerable nonuniformity in the characteristics of the regulator-amplifier tube V131. These deficiencies are corrected respectively by changing the voltage-dropping resistor R256 from 47,000 ohms to 18,000 ohms, mounting the suppressor resistors R257, R258, and R259 directly on the tube sockets, removing wiring to the regulator-output control R253 from the cabled harness, and using a 6AC7 instead of a 6SJ7 for V131. These changes reduce output ripple voltage by as much as 75 per cent in most cases.

6. Second-anode circuit of theCathode-ray Tube — A reduction in the astigmatic distortion of the trace may be accomplished by reducing the change of voltage on the second-anode element of the cathode-ray tube. This is effected by reducing the resistances of the bleeder resistors R177 and R178 from 470,000 ohms to 82,000 ohms. The voltage drop in R177 resulting from the flow of current through the second anode of the cathode-ray tube at high beam intensities is thereby greatly reduced. Thus, the average potential between a deflecting-plate pair and the second anode is kept within tolerable limits of approximately 0 to 40 volts over the range of the intensity control.

Chronology — It is difficult to specify the exact serial numbers of instruments in which the foregoing changes first appeared. Furthermore, in some cases modifications of a given circuit were made at different times. Some of the changes, however, and the serial numbers of the instruments in which these changes first were incorporated are listed in Table I.

Summary — Considerable improvement in the operation of the Types 248 and 248-A Cathode-ray Oscillographs has been effected since the early stages of their production. As described above, these improvements have resulted from modifications of circuit design due largely to contact with the people using these instruments, and from an accumulation of experience with the problems of the design. Special facilities have been set up to modify old instruments in a very short time. Further information can be obtained from Mr. G. C. Seymour, Instrument Service Dept., Instrument Division, Allen B. Du Mont Laboratories, Inc., 1000 Main Avenue, Clifton, New Jersey. All inquiries should include serial numbers of the instruments so that records can be checked for the extent to which the above modifications have been incorporated. On the basis of such information, a quotation can be made of the cost of performing the necessary modifications. Following the modification, each instrument receives a thorough performance test and, excepting for tubes, a new-instrument guarantee.

— R. P. Abbenhouse.

TABLE I

Modification	Serial No.
1. Beam brightening ..... approximately	375
2. Sweep-linearity correction and sync amplifier decoupling ..... approximately	430
3. Amplitude limiting of sawtooth applied to cathode follower V118	674
4. Marker generator stabilizing and damping of series-peaker output of V109	590
5. Stabilizing of VR, tube, regulation	530
6. Ripple reduction in regulated power supply	623

Oscillographic Crystal Mode Analyzer

A New Device Probes Response Regions of Piezo-electric Crystals, Enabling Rapid Examination of Complex Response Spectra

A new instrument intended as a research tool for exploring the response regions of a piezo-electric crystal quickly reveals a crystal's array of resonance responses. And by making these interference phenomena obvious, the device — developed by Mr. Gunnar Hok at Wesleyan University — serves as a rapid, efficient indicator of crystal quality. This instrument, used in conjunction with the Du Mont Type 250 Cathode-ray Oscillograph,[1] saves considerable time by making a preliminary examination of a complex response spectrum before entering upon the more time-consuming process of point by point bridge measurements of the crystal's properties.

The electrical response of a piezo-electric crystal is complicated by the many mechanical resonances of the piece of crystalline material. When the frequency of the desired resonance is determined primarily by the thickness dimension, the frequency region of this resonance is likely to be infested with secondary resonances. These resonances are high overtones of other resonating dimensions, and the frequencies of these may be so close as to couple to the desired mode.

[1] The Dumont Type 247 was used during the development of the Crystal Mode Analyzer. This oscillograph has since been replaced by the Du Mont Type 250.

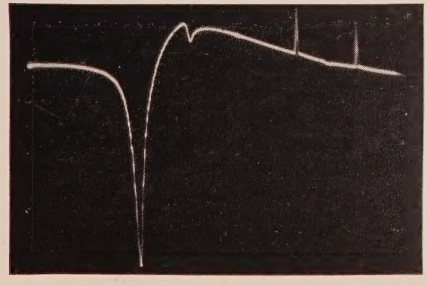


Figure 1. Response of a 1.92 mc. AT cut crystal with a variable air gap. Large downward-going pip indicates fundamental shear mode. Smaller pip to right is flexture mode. Small upward-going pips are timing markers.

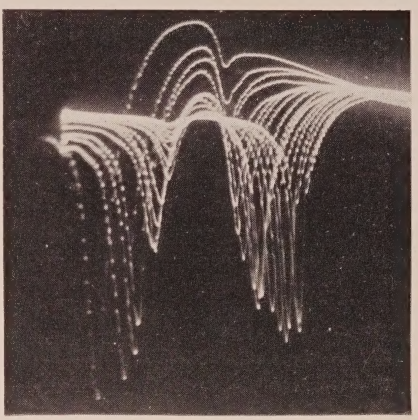


Figure 2. Multiple exposure showing inter-mode coupling. As air gap increases, fundamental shear mode decreases, moves to right. Flexture mode increases, moving leftward.

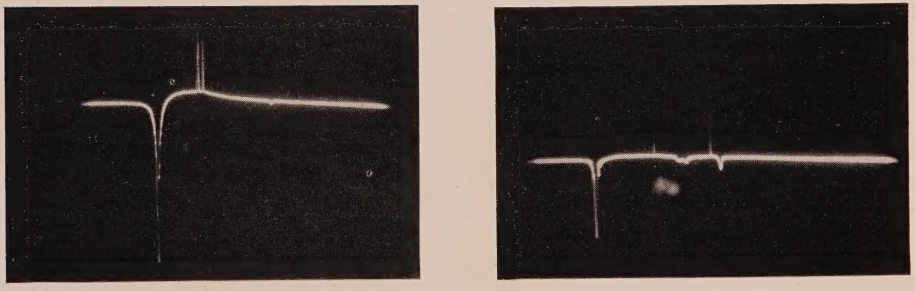
Temperature variation, or a change in air gap, may cause the resonant responses to shift with respect to each other. Some temperature or some condition of mounting may be just right for causing interference between the two resonances. For thickness shear crystals which have been finished to have good activity at room temperature, the dips in activity which occur when the activity test is extended over a range of temperatures have long been "bugaboos" of crystal manufacturing.

The resonances which this instrument portrays most prominently in the immediate neighborhood of the thickness shear fundamental are those of secondary modes of thickness shear. In these modes the face of the plate subdivides in Chladni

plate fashion with nodal lines in the surface of the plate. Each of these resonances is directly driven piezo-electrically, that is, independently excited by the electrical field of its characteristic frequency. These particular secondary resonances are extremely troublesome in filter applications where the admittance of the resonance must be high in only one band of frequencies.

Another set of secondary resonances is the principal trouble maker in crystals for many oscillator or frequency-control applications. These resonances are high overtones of some mode other than thickness shear, often a flexure whose fundamental frequency depends on the length or width of the plate. Such overtones, whose ordinal number may run as high as 100, are driven mechanically by the resonant vibration of the desired thickness shear mode and require intense response of the latter to make them prominent. These high overtone modes are excited at such low levels when their frequencies are slightly removed from the main thickness shear mode, that no significant effects of their existence are then noted. If, due to temperature change, air gap, or a readjustment of crystal dimensions in refinishing, the frequencies of the thickness fundamental and one of these overtones come sufficiently close to each other, then this secondary mode is driven by the resonant response of the main mode and may show a resonance of its own which is comparable in magnitude to that of the main mode. The phenomena of coupling, so familiar in high-frequency circuits, show up in the frequencies of the two modes. The coupling vibrations, however, are mechanical rather than electrical.

The crystal mode analyzer, built in connection with a study of the circuit properties of crystals carried on for the Signal Corps, probes the response regions of a crystal and brings to light these troublesome resonance responses. The crystal under observation is placed in a bridge circuit. The frequency of a driving oscillator is then electronically swept past the crystal resonance, periodically and in sawtooth fashion. In order that the sweeping rate may be rapid enough for convenient operation, the high Q of the crystal, which is commonly in the hundreds of thousands, is reduced somewhat by the bridge circuit. The spot of a Du Mont Type 250 Cathode-ray Oscillograph is swept slowly across the long persistence screen in synchronism with the sweep of frequency through the resonance range. The horizontal deflection of the spot constitutes a frequency scale. The vertical deflection, actually downward, portrays the admittance of the series resonant motional admittance chain of the crystal, thus tracing an inverted resonance curve. Several such downward deflections displayed along the frequency scale indicate the several



(*a*) (*b*)

Figure 3

(*a*) *An oscillogram of the spectrum of a two-inch AT-cut crystal at the thickness-shear fundamental. Calibration marks are at* 680 *kc* (± .56 *kc*). (*b*) *The spectrum of the same crystal at the thirteenth harmonic. Here the calibration marks are at* 8.814 *mc* (± .00056 *mc*).

resonances near the main mode. Dials shift the frequency scale along the face of the oscillograph. Other dials alter the frequency deviation of the scale and permit a single resonance to be spread out so that it occupies the full face of the screen. The spreading-out is often convenient for observing the character of a secondary mode which is part way up the slope of a main mode.

Ringing of the crystal under test occurs when the sweep rate is too fast for the effective Q of the crystal in the bridge circuit. But the faster sweep and high repetition rate which are available when needed simplify locating a desired resonant region. Experience indicates that most crystals which are of interest are coupled closely enough to the bridge circuit piezo-electrically to be free from ringing when the sweep repetition rate is kept down to one sweep in two seconds. The D-C sawtooth voltage for sweeping the frequency by means of a reactance tube is taken directly from the Du Mont instrument.

Calibration markers are used to determine resonance frequencies as they appear on the screen. These markers consist of a pair of upward-deflected pips which are 6.4 kc apart and may be moved along the frequency scale at will. In any fixed position the frequency of either is determined by comparison with an external standard. The frequency range of the present instrument is from 500 kc to 10 kc. Two other instruments are under test for portraying bands immediately above and below this frequency range on the same oscillograph.

THE 1949 I.R.E. SHOW

The Radio Engineering Show of the 1949 I.R.E. National Convention opens March 7 at Grand Central Palace, New York City, running until March 10. The latest developments in all branches of radio engineering will be on display in more than 200 exhibits.

Allen B. Du Mont Laboratories, Inc., of course, will be well represented. The Television Transmitter Manufacturing Division will have a number of displays at booths 243-247. The Instrument and Tube Divisions, occuping booths 125-128, will exhibit the complete line of Du Mont oscillographs and associated equipment, and the latest in industrial cathode-ray tubes.

Among the interesting Du Mont exhibits will be such demonstrations as the operation of the Du Mont Type 314 Oscillograph-record Camera; projection oscillography with the Du Mont Type 250-H Oscillograph used in conjunction with the new Du Mont Type 2542 Projection Lens; the Du Mont Type 279 Dual-beam Oscillograph, displaying simultaneously the input and output voltage and current of a voltage regulator; and a Du Mont Type 275-A Polar-coordinate Indicator showing the differences in light distribution patterns of two incandescent lamps with pre-focused, molded lenses, one perfect, the other imperfect.

All visitors to the Radio Engineering Show are invited to stop at the Du Mont booths to see the latest in oscillography.

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